ABBREVIATED NOTES

ON

MILITARY ENGINEERING.

From Can. for...
M. D. Dept.

Institution of Royal Engineers

ABBREVIATED NOTES ON MILITARY ENGINEERING.

PUBLISHED BY

THE R.E. INSTITUTE, CHATHAM.

(*From Notes originally compiled for use by the 9th Co., R.E.*).

SIXTH IMPRESSION, CORRECTED TO 1ST JANUARY, 1916.

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ABBREVIATED NOTES ON MILITARY ENGINEERING.

ROPES, SPARS, TACKLES, STRENGTH OF MATERIALS.

1. The safe working strains of rope are as follows:—

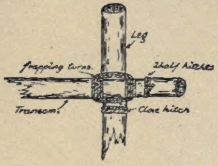
When C=Circumference in Inches.

Ordinary cordage	$= C^2$ cwts
Ditto (if new and in good condition) ..	$=2C^2$ cwts
Steel wire rope	$=9C^2$ cwts

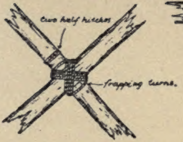
2. The strength of a square or diagonal lashing $=\frac{4}{5}\times 4\times$number of turns$\times$strength of rope.

The strength of a round lashing$=\frac{4}{5}\times 2\times$number of turns$\times$strength of rope.

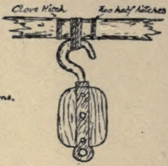
The above are for lashings of cordage. When using wire rope substitute $\frac{3}{5}$ for $\frac{4}{5}$ in above formulæ owing to the difficulty in keeping the turns taut.



(four turns.)
— Square Lashing —



(four turns.)
—Diagonal Lashing.—



(four turns)
-Round Lashing.—

3. The gain in power of a tackle depends upon the number of returns from the movable block.

4. The friction of each sheaf of a block $=\frac{1}{10}$th to $\frac{1}{8}$th the power applied for tackles in excellent conditions, $\frac{1}{6}$th for average tackles.

5. Where P = power to be employed,

W = weight to be lifted (in the same unit as P),

G = gain in power of tackle (*i.e.*, number of returns from the movable block, including standing or fixed end of the fall, if secured to movable block). N.B.—The running end also counts, if coming off the movable block,

n = number of sheaves (including snatch-blocks if used),

f = coefficient of friction, *i.e.* $\frac{1}{10}$th to $\frac{1}{6}$th,

then
$$P=\frac{W}{G}(1+fn).$$

6. A 5′ picket well driven at 2/1 will hold about 7 cwt. in good firm soil. And similarly a 3.2.1. holdfast of 5′ pickets will hold about 2 tons.

7. The largest fall a block will take has a circumference of about $\frac{1}{3}$rd length of shell of block (only applicable to wooden blocks).

8. If a tackle twists a complete turn, the power required is increased by over 40%. To prevent a heavy tackle twisting, place a handspike between the returns and lash it to the block.

9. If a rope is twisted by a Spanish windlass three times, it is estimated that it is weakened by $\frac{1}{8}$th.

10. New rope should always be stretched before being rove in a tackle.

11. A man on level ground pulls about 80 lbs. horizontally.

12. A single block, usually a snatch-block, is employed as a leading block to alter the direction of the pull on a tackle (usually to a horizontal pull); it gives no gain in power, but the friction of the sheaf must be considered.

13. A derrick is a single spar set up with four guys for lifting and moving a weight in any direction; a swinging arm is sometimes fixed to the derrick (it is then known as a swinging derrick) to obtain a greater lateral movement. In a swinging derrick the weight can be moved laterally through an angle slightly greater than 90°, and carried backwards and forwards by raising and lowering the head of the swinging arm. The safe limit of incline for standing derricks is 3/1, but when first raised they should not be at a

flatter slope than about 5/1, as when the guys stretch, the slope will become the limit of safe working. The strain then on the back guy is $\frac{1}{2}$ of the weight being raised.

14. Sheers are composed of two legs, and allow of a backward and forward movement of the weight only. The feet of the sheer legs should be apart $\frac{1}{3}$rd of length of leg from butt to lashing. Sheers should not be canted over more than $\frac{1}{3}$rd of their height; the strain on the back guy is then about $\frac{6}{10}$ths of the weight lifted.

15. The holdfasts for the guys of derricks and sheers should be at least twice as far from the feet of the derrick or sheers as their height.

16. A gyn is composed of three legs, requires no guys, and is used for lifting a weight vertically only. The feet of a gyn should be apart $\frac{1}{2}$ of length of leg from butt to lashing.

17. The weight of infantry in fours crowded = 5 cwt. per foot-run. A bridge that will carry infantry in fours crowded will also carry cavalry in file, field guns, 4·5″ howitzers, and ordinary loaded wagons.

18. The working strength of an unselected spar or baulk of fir or similar wood can be calculated as follows:—

When W = actual distributed weight on spar or baulk in cwts.,
b = breadth of baulk in inches,
d = depth of baulk in inches or mean diameter of spar in inches,
L = length of span in feet, *i.e.*, length of spar or baulk between supports,

then

(a). For round spars .. $W = \frac{6}{10} \times \frac{d^3}{L}$.

(b). For baulks .. .. $W = \frac{bd^2}{L}$.

For English oak and similar strong hard woods W may be taken as $1\frac{1}{2}$ to $1\frac{3}{4}$ times its value given by the above formulæ.

(*Note.*—In calculations for strength of baulks and spars in bridges it must be borne in mind that :—

(1). These formulæ include a factor of $1\frac{1}{2}$ for live load.

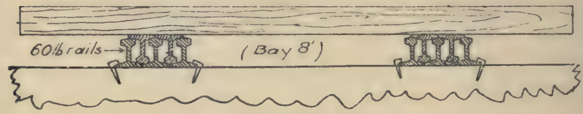
(2). The weight of superstructure for a bridge for ordinary wheel traffic is allowed for in the formulæ.

(3). A factor of safety of 3 is included in the formulæ.

(4). When using concentrated loads (such as heavy guns or traction engines) the weight must be multiplied by 2, to convert it into equivalent distributed load before using the above formulæ).

19. A steel rail, 60 lbs. per yard-run, will take a safe distributed load of 3 tons approximate over a span of 8′, and $2\frac{1}{3}$ tons approximate over a span of 10′. Similarly a steel rail, 80 lbs. per yard-run, will take a safe distributed load of $4\frac{1}{2}$ tons approximate over a span of 8′ and $3\frac{3}{4}$ tons approximate over a span of 10′. Five 60-lb. rails under each rail are good

enough for all engines over a span of 8′. They should be arranged thus :—



Section.

20. The following Table gives some ordinary standard sizes of steel girders showing what distributed weight they may be expected to take over certain spans. It is impossible to give more than a few ; should other sizes and spans be met with, a fair approximation can be made by comparing them with those given in the Table.

Table showing Safe Distributed Loads in Tons for I Section Rolled Steel Girders over various spans.

Size in Inches.	Thickness of Flange, inches	Span in Feet.								
		8	10	12	16	20	24	30	36	40
4 × 3	·3	2·3	1·9	1·6	...	...	...	...	...	...
5 × 3	·4	3·4	2·7	2·3	1·7	...	...	...	...	...
5 × 4½	·4	5·6	4·5	3·8	2·7	...	...	...	...	...
6 × 3	·5	5·4	4·4	3·6	2·6	...	...	...	...	...
7 × 4	·4	7	5·6	4·7	3·4	2·7	...	...	...	...
8 × 4	·6	12	9·3	7·7	5·7	4·5	...	...	...	..
8 × 5	·6	14	11	9	6·8	5·3	...	...	...	...
10 × 5	·6	18	14	12	8·8	6·9	5·6	...	...	...
10 × 6	·7	26	21	17	13	9·7	8·4	...	...	...
12 × 6	·9	39	31	26	19	15	12	9	...	...
15 × 6	·9	52	42	35	26	20	16	13	10	...
18 × 7	·9	78	64	53	39	31	25	20	16	...
24 × 7½	1·0	..	101	91	68	54	45	35	29	25

Note.—The loads given are the actual loads that may be placed on the girder, and do not include the weights of the girders themselves, which have been accounted for.

The above Table is of course only of use for comparatively small girders ; but these are probably the ones that will be met with in small bridges, the strength of which for heavy military traffic (such as mechanical transport) it may be necessary to determine.

21. In cases in which an allowance is not made in a formula for live loads it may be necessary to

multiply the live load by $1\frac{1}{2}$ or 2 to convert it into equivalent dead load. An example of this is the strength of the back guy of a pair of sheers or a derrick; in calculating the size of this guy the weight to be lifted should be multiplied by $1\frac{1}{2}$ to allow for the jerkiness in pulling (*i.e.*, the live load) always met with when squads of men are employed.

22. One cubic foot of water contains $6\frac{1}{4}$ gallons.

23. One gallon of water weighs 10 lb.

24. The safe buoyancy of a cask or barrel may be determined as follows :—

(*a*). Roughly.—Multiply its capacity in gallons by 9; this will give its safe buoyancy in lbs.

(*b*). More accurately.—

Where C = mean circumference of cask in feet,
L = length of cask in feet,
W = weight of cask in lbs.,

$$\text{Safe buoyancy} = \tfrac{9}{10}\,(5\,C^2\,L - W)\ \text{lbs.}$$

25. Safe buoyancy of a closed vessel may be determined as follows :—

Where W = weight of vessel in lbs.

$$\text{Safe buoyancy} = \tfrac{9}{10}\,\left((\text{cubic capacity in cubic feet} \times 62\tfrac{1}{2}) - W\right).$$

26. Safe buoyancy of a log or other solid can be found in lbs. by multiplying its cubic contents in cubic feet by difference between 1 cubic foot of water ($62\frac{1}{2}$ lbs.) and its weight per cubic foot.

27. Approximate weight of timber is as follows :—

Fir	33 lbs. per cubic foot.
Oak	54 lbs. per cubic foot.

28. The cubic contents of a round log or spar can be roughly obtained as follows :—Multiply the square of the mean radius in feet (*i.e.*, the square of $\frac{1}{2}$ mean diameter in feet) by 3, and multiply the result by the length of log or spar in feet. For example :— Find cubic contents of a 15′ spar having a mean diameter of 8″.

Mean radius therefore $=4'' = \frac{1}{3}'$.

Therefore square of mean radius $= \frac{1}{3} \times \frac{1}{3} = \frac{1}{9}$.

Therefore cubic contents = square of mean radius in feet $\times 3 \times$ length of spar in feet $= \frac{1}{9} \times 3 \times 15$ cubic feet $=5$ cubic feet.

BRIDGING.

29. First take the section of the gap to be bridged by boning and levelling, taking accurate heights of the trestles or frames. In water the heights must be taken by sounding with a pole. Lay out the section on the ground. Then in frame and tension bridges allow $\frac{1}{60}$th of span for camber. In trestle bridges allow a camber of 1/30 for about 30′ from either end of the bridge. In the case of suspension bridges the rise should be continued up to the centre of the span. If the ground is very irregular it may be necessary to take a separate section for each line of trestle legs.

30. The object of a camber is to get loads quietly and slowly on to a bridge, to get them easily off, and to prevent their stopping in the centre. In soft

ground an extra allowance for subsequent settlement must be made.

31. In the construction of trestles always square the trestle before lashing the tips of the braces. Further, keep the braces well down below the transom, so that if necessary the transom may be lowered afterwards by beating down the transom lashings without the transom jamming on the points of the braces.

32. The normal width of roadway for military bridges is 9′ in the clear between ribands. This means 10′ 6″ between standards at the transom.

33. The legs of a trestle bridge should be given a splay of 6/1. This may be calculated thus :—Add to length of transom between standards ⅓rd of the distance between the transom and the ledger ; this will give the length of the ledger between the legs.

34. In constructing trestles in muddy soft ground keep the ledgers low ; in rocky ground keep the ledgers high.

35. In trestle bridges longitudinal bracing should always be provided between trestles to prevent the trestles being pushed over by the roadbearers as the weight comes on to the bridge.

36. A 3-legged trestle is constructed by joining two poles with a sheers-lashing and adding a third pole as a pry-pole, and fixing on the necessary ledgers. Three-legged trestles can be made of light material, are stiff, stand without bracing, admit of ready adjustment of the transom, but are unsuitable for uneven bottoms and difficult to place.

The legs should splay at 6/1.

37. Four-legged trestles are useful as steadying points in a long trestle bridge. The frames should have a slope of 4/1.

38. In calculating the strength of spars or baulks, etc., for bridges :—

(*a*). The transom must take the weight of one bay of the bridge.

(*b*). Each inside roadbearer must take the weight of one bay of the bridge, divided by the number of roadbearers less one ; the reason for this being that each outside roadbearer only takes half weight taken by each inside roadbearer.

(*c*). The load on a transom can always be taken as "distributed" ; the load on roadbearers however may sometimes have to be taken as "concentrated."

39. If in temporary bridge work, subject to the shock of live loads, the factor of safety is reduced to 2, the materials often approach dangerously near to their elastic limit ; therefore a factor of safety of at least 3 must be insisted on.

40. To find the safe buoyancy of a boat see how many men are required to sink it to 1′ free-board ; the weight of the men gives the buoyancy. The average weight of a man is taken as 160 lbs.

41. In floating bridges the waterway should not be less than the total width of the piers or boats.

42. The length of piers or boats in a floating bridge should not be less than double the width of the roadway.

43. In using boats for bridge work, place them

bow upstream, or in tidal water, alternately up and downstream.

44. The following depths are fordable :—

For Infantry	..	..	..	3′
For Cavalry	..	..	..	4′
For Artillery	..	..	..	2′ 4″

45. Buoyancy of one pontoon (*i.e.*, two sections) with a minimum safe free-board (*i.e.*, 12″) = 6,050 lbs.

46. Medium pontoon bridge will carry infantry in fours crowded (see para. 17).

FIELD DEFENCES.

47. Field defences are designed for protection and concealment. Protection can only be given from rifle bullets, shrapnel, and splinters of shell. It is useless to spend time and labour on making parapets, which are proof against the impact of the shells themselves, the only protection from these being concealment and invisibility. Light field gun common shell will not however make much impression on any parapet. Dug-outs can be made "light shell proof." That is proof against all but the largest howitzers. Dug-outs should never be made under the front parapet.

48. The "command" of a work is the height from the natural ground level to the top of the parapet.

49. A "relief" is the working period of a working party.

50. A "task" is the amount of work a man has to perform in one relief.

51. A "traverse" is a stop in a line of trench to secure the occupants from enfilade fire, and to localise the effect of a shell bursting in the trench. Unless a

traverse is bullet proof it is useless. Therefore the minimum thickness of a traverse must be at least 3′. Thicker traverses are however advisable, 6′ being a useful breadth.

52. Tracing a work consists in laying out with tapes the cutting lines on the ground to guide a working party. It is usually only necessary to lay out one front cutting line, and for ordinary trenches no tapes are required.

53. In a four-hour relief a man can excavate *in ordinary soil* with service tools 80 cubic feet, with a maximum horizontal throw of 12′ and a maximum vertical throw of 4′.

54. A working party for digging can be worked for four hours and rested for eight alternately and continuously. So, if a work requires to be carried out for a considerable time without a check, three times the number of men are required than the actual working party. For lighter work (*e.g.*, obstacles, clearance of foreground) men can be worked for four hours and rested for four hours continuously.

55. Men should not be made to work closer than 4′ on a line of trench. The normal distance apart of diggers is 5′.

56. In demanding working parties add $\frac{1}{10}$th for a reserve to the numbers actually required for the work.

57. In selecting the site for trenches the following points must be considered :—

(*a*). Concealment of trench from aircraft and artillery observers.

(*b*). Field of fire up to 200 yards.

(*c*). Ground in rear suitable for reserves.

(*d*). Good communication with firing line.

58. In designing a trench first determine the minimum command necessary and work from that.

59. To test the penetration of any substance, fire at it at about 200 yards, as it has been found by experiment that the bullet is steadied in its flight by then, and is not affected by the muzzle blast, and so penetrates further than at point blank range. Minimum safe thicknesses against rifle bullets at present in use at close range are :—

Clay	5′
Ordinary soil (unrammed) ..	3′
Chalk	2′
Sand between boards	1′ 6″
Shingle between boards	6″
Brickwork (well built)	9″
Wrought-iron plate	$\frac{7}{16}$″

60. A trench should be made as invisible as possible.

61. The interior slope should be as steep as possible.

62. In revetting, normal slope of revetments is 4/1.

63. A man requires the following cover, irrespective of head-cover :—

Lying	1′
Kneeling on one knee ..	3′
Kneeling on both knees ..	3′ 6″
Standing	4′ 3″ to 4′ 6″

64. A man requires an elbow rest when standing or kneeling on both knees 9″ below the crest and 9″ wide. In many cases no elbow rest is given.

65. A man requires 18″ to stand upon.

66. A passage behind the firers in a trench should be not less than 2′ wide.

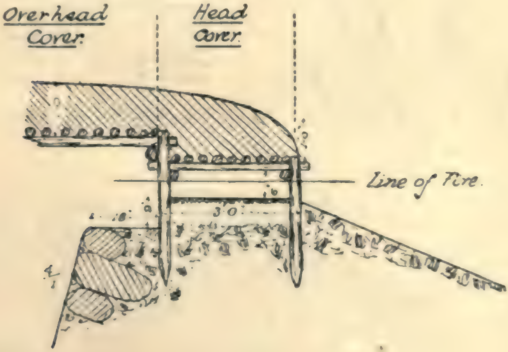
67. A man requires from 2′ to 2′ 6″ to kneel on both knees.

68. A man requires 6′ to lie on.

69. At least 3′ of earth must be maintained in front of the diggers during the work, so that the trench, though incomplete, may be of use at any moment. Diggers should make a point of getting protection for themselves as soon as possible.

70. Head-cover of earth should be from 4″ to 6″ above the crest, 1′ deep and 3′ thick.

71. Overhead cover of earth must be at least 1′ thick to be proof against shrapnel and splinters of shell. Head cover makes a trench more conspicuous, while overhead cover makes it hard for the defenders to get out of their trench to repel an attack with their bayonets.

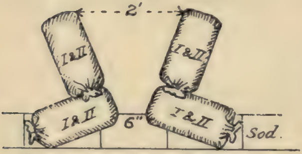


72. Loopholes can be made thus :—

Depth of loophole from 4″ to 6″. Loopholes should not be closer than 3′ centre to centre. Loopholes constructed of stone should always have the narrow opening on the outside of the work. Loopholes sited to fire obliquely are useful for snipers ; the opening of an oblique loophole not being so obvious to an enemy directly in front

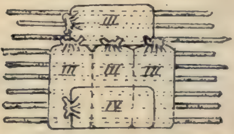
SANDBAG LOOPHOLE.

Fig. 3



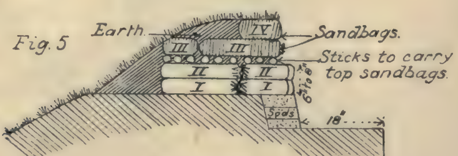
FLAN OF I & II COURSES

Fig: 4



PLAN OF III & IV COURSES

Fig. 5



SECTION.

73. Loopholes should be so constructed that they cannot be made use of by the enemy from the outside. Loopholes not in use to be blinded.

74. In defending a hedge or existing obstacle no earth or signs of defence should be thrown or appear on the exposed side which would assist the enemy in locating the position.

75. In estimating length of trench for a firing line under ordinary conditions 1 to 1½ men per yard-run, including supports and local reserves, is taken as a normal garrison.

76. A battalion carries approximately*:—

76 picks.
110 shovels.
90 cutting tools.

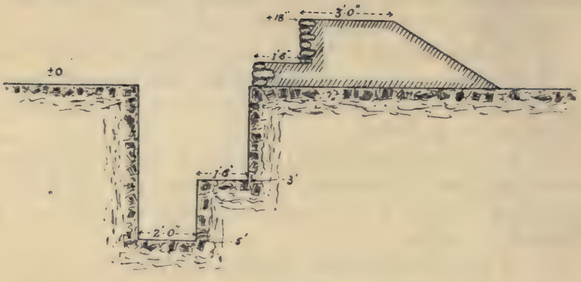
A Field Company, R.E., carries approximately :—

100 picks.
130 shovels.
150 cutting tools.

77. To calculate out time and men required for a length of trench—first, having designed the trench, find out the area of its section in square feet, then multiply this by the length of a task ; the result will be the number of cubic feet to be excavated in each task. Knowing that 80 cubic feet are excavated in four hours, it can be seen what proportion of 80 cubic feet the excavation is, and therefore how long it will take, in ordinary soil. The number of men required =length of trench ÷ length of a single task.

* The bulk of the tools are carried in the Brigade Headquarters.

Example :—



The task is 5′ along the line. The area of the excavation is :—

$(5 \times 2)+(3 \times 1\frac{1}{2})$ square feet $=14\frac{1}{2}$ square feet.

∴ cubic feet in each task $=14\frac{1}{2} \times 5 = 72\frac{1}{2}$ cubic feet.

∴ work will take $\frac{72\frac{1}{2}}{80}$ of 4 hours $=\frac{9}{10}$ of 4 hours approximately.

$=3 \cdot \frac{3}{5}$th hours (4 hours).

And if 40 yards of trench have to be excavated, men 5′ apart, there will be required $\frac{40 \times 3}{5} = 24$ men.

78. Fire trenches should be kept as narrow as possible. Communication trenches should be at least 3′ 6″ wide to allow stretchers to be carried along them. All trenches should be drained. Trenches may be easily drained by open drains to low ground, or by soak pits at intervals covered with wooden gratings : or if the soil is clay, by pits which can be

cleared out by dipping buckets or by small hand pumps.

79. Clear the immediate foreground of a defensive position as soon as possible, doing further clearing later as time permits; but have look-out men well in advance to prevent surprise when working far from the trenches.

80. Put out or note range marks in front of the trenches; natural objects will do in most cases.

81. In placing obstacles the following conditions should be observed:—

- (*a*). Obstacles to be under close fire of the defenders.
- (*b*). Obstacles to afford no cover for enemy.
- (*c*). Obstacles to be difficult to remove, destroy, or surmount.
- (*d*). Obstacles to be concealed from attacking force.
- (*e*). Obstacles to be arranged so as not to impede counter-attack.

82. A man can construct 10 square yards of low wire entanglement (as given in *M.F.E.*) in one hour, and requires 1′ of wire for every square foot of entanglement; high wire entanglement (as given in *M.F.E.*) takes three times as long, and requires three to five times as much wire.

83. A man can cut 100 square yards of brushwood (up to $1\frac{1}{2}''$ diameter approximately) in four hours; this does not include clearing away.

84. Always get a continuous line of obstacles in front of a trench as soon as possible.

CAMPING ARRANGEMENTS.

85. The following are the minimum camping and bivouacking spaces for temporary camps and bivouacs on flat ground (when space for parade ground is not required) :—

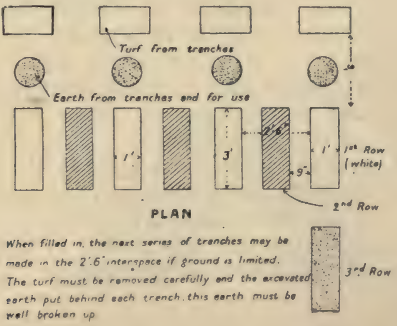
Cavalry Regiment	.. ..	6 acres.
Cavalry Squadron	.. ..	$2\frac{1}{2}$,,
Battery of Artillery	.. ..	$2\frac{1}{3}$,,
Field Company, R.E.	.. ..	$1\frac{1}{4}$,,
Infantry Battalion	.. ..	$2\frac{1}{2}$,,

About double this space should be allowed for standing camps ; this allows for moving tents when necessary and also gives room for a parade ground. (*N.B.*—1 acre=70 yards × 70 yards).

86. In constructing field kitchens or ovens the kitchen or oven trenches should face the prevailing wind.

87. The ordinary trench (10′) of a kitchen will cook for 120 men. Trenches should not exceed 10′ in length.

88. The form of latrine trench for use in camp should be as shown in sketch :—



Each trench lasts one day. Five trenches are allowed per 100 men.

89. If water supply is drawn from a stream, arrangements for supply should be made as follows :—

(*a*). Farthest upstream ...	Men's drinking and cooking water ...	Denoted by White flag.
(*b*). Next	Horses' drinking water	Blue flag.
(*c*). Next	Men's washing and bathing	Red flag.
(*d*). Lowest downstream	Refuse water, drainage, etc., let into stream if necessary.	

90. The following allowances of water per day should be made :—

3 to 4 pints for drinking
3 to 4 quarts for drinking and cooking
3 to 4 gallons for drinking, cooking, and washing
} per man.
8 gallons per horse.

It is found that once a piped water supply is given to a standing camp that the amount of water used per man and horse goes up considerably ; each man and horse using about 10 gallons per day.

91. In calculating amount of troughs for horses allow each horse if possible a space of 4′ and five minutes to drink, and arrange for all horses to water within one hour. In hot weather a horse may drink 4 gallons at one time.

With seasoned horses or when horses are tired the space between animals given above can be halved.

92. The best way of purifying water is by boiling it ; it should then be aerated by pouring from one vessel into another.

93. The lift and force pump in general use in the Service can lift water 28′ and force water 32′, or lift and force water 60′ in all (maximum lift 28′), at a rate of 12 gallons a minute.

94. Pipes for supplying water by gravity must be laid below the hydraulic mean gradient to obtain full delivery, *i.e.*, the line of pipe must be kept below the line joining the point from which the supply starts to the point of delivery.

95. In arranging the water supply of a camp involving the use of iron water pipes it must be remembered that a certain amount of the " head " of water is consumed by friction of the water passing through the pipe, whether the water flows by gravity or is pumped through the pipe.

The following Table shows in feet the head of water consumed by friction in each 100′ *length* of pipe :—

Delivery Gallons per Minute.	Internal Diameter of Pipe in Inches.					
	½	1	1½	2	3	4
5	230	7	0·8	0·2	0	0
10	...	117	3·5	0·8	0	0
20	...	108	14	3	0·25	0
30	...	...	31	7	0·6	0·1
40	...	...	55	12	1	0·25
50	...	...	86	20	1·6	0·4
60	...	...	...	28	3	0·5
80	...	...	...	50	4	1
100	...	...	...	78	6	1·4
150	...	...	...	...	14	3·25
200	...	...	...	...	25	5·7

Note.—Elbows, bends, angles, and fittings considerably increase the friction. If therefore they are numerous in the pipe line, make some extra allowance for them.

Pumps are denoted by their horse-power (H.P.).

The following formula gives the break horse-power of any pump required :—

Where G = number of gallons of water required per minute,

(*Note.*—10 lbs. = weight of one gallon of water),

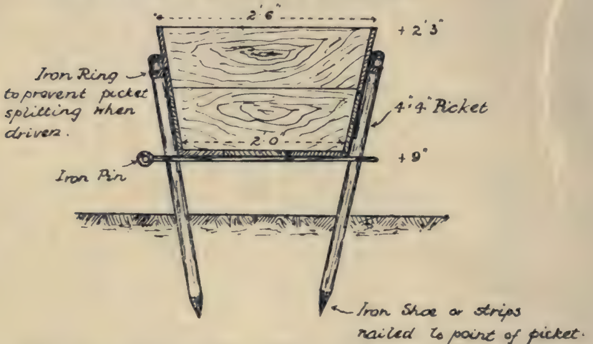
H = actual number of feet (*i.e.*, actual head in feet) it is required to lift the water,

H_1 = head in feet lost by friction, as given by above Table,

then B.H.P. of pump $= \dfrac{G \times 10 \times (H + H_1)}{33,000}$.

96. In standing camps it may be necessary to construct wooden horse troughs. They should be always

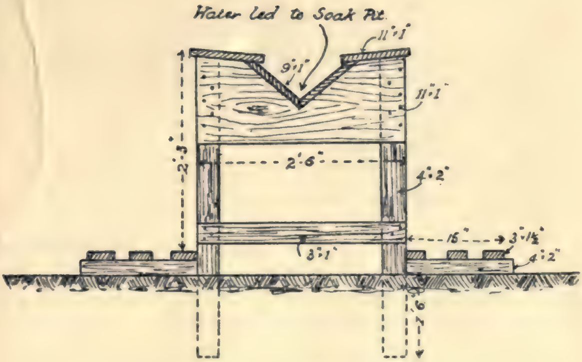
large enough to allow watering from both sides ; a suitable pattern is as shown in sketch.



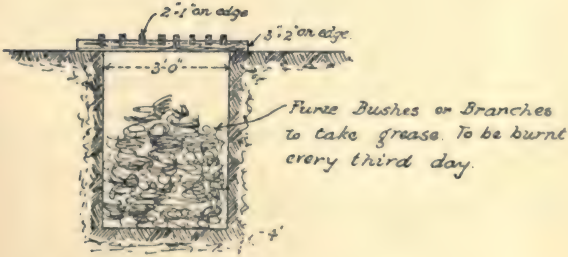
97. For standing camps a convenient form of men's washing bench is as shown in sketch. 15′ run of bench per 100 men is a suitable allowance.

98. In standing camps a soak pit for greasy water should be dug near every cookhouse ; this should be covered with a wooden grating as shown. The pit should be filled with gorse or furze, which catches the grease and can be burnt every third day and replaced. This prevents an impermeable layer of grease being formed in the bottom and on the sides of the pit.

The destruction of grease, soapsuds, etc., in a standing camp is a big business. In rest camps with piped water supply 1,000 men will produce as much as 1½ tons per month of solid grease from cookhouse and ablution waste pipes. Before letting this waste water go to soak pits it should pass through a settling tank with a scum board. The settling tank to be cleaned daily. The grease should be scooped out, dried and burnt.



—Ablution Bench.—



—Greasy Water Pit.—

(3'·3'·4')

DEMOLITIONS.

99. The following is the approximate amount of guncotton carried by units in the first line transport :—

Cavalry Regiment	.. ..	150 lbs.
Field Troop, R.E.	.. ..	320 ,,
Field Company, R.E.	.. ..	600 ,,

100. "Tamping" is covering the charge with earth or other material so as to obtain a greater result from the explosion. Gunpowder charges must always be tamped. With guncotton, cordite, or dynamite tamping is not so necessary as with gunpowder.

101. When using guncotton for demolitions the charge must be in close contact with the object to be destroyed ; all slabs must touch one another, and the primer must be kept tight against the wet slabs.

102. Before use dynamite must be thawed,if frozen, but not near a fire. It freezes at about 40° (Fahr.).

103. In making up simultaneous charges with instantaneous fuze all pieces of instantaneous fuze must be of the same length.

104. Guncotton and gunpowder charges may be calculated as follows :—

Where B=length to be demolished in feet,
T=thickness ,, ,, ,,
t= ,, ,, ,, in inches,
C=circumference of cable in inches,
T′=total distance from the surface of the lining to the charge,

then :—

(a). *Using Guncotton* (Untamped Charges).

For brick arches	..	charge	$=\frac{3}{4}$ BT^2 lbs.
,, ,, piers	..	,,	$=\frac{2}{3}$ BT^2 ,,
,, iron or steel girders		,,	$=\frac{3}{2}$ Bt^2 ,,
,, wire cables	..	,,	$=\frac{C^2}{24}$ lbs.

(If tamped, reduce charges by 50%).

(b). *Using Gunpowder* (Tamped Charges).

For brickwork	charge	$=\frac{2}{3}$BT^2 lbs.
,, tunnels	,,	$=\frac{2}{5}$T$'^3$ lbs.

Add 50% to the charge in the presence of the enemy.

105. When using cordite the amount of the charge and the method of detonation is the same as for guncotton.

106. In demolishing a railway line the following should be remembered :—

(a). Destroy the "points" when possible, as they are difficult to repair.

(b). Destroy signalling apparatus, telegraphs, workshops, and water supply.

(c). To destroy a tunnel blow it up near both ends, as repair will take longer when working only on one side of the demolition.

107. To cut an iron or steel girder with guncotton place three charges (to be fired simultaneously), one

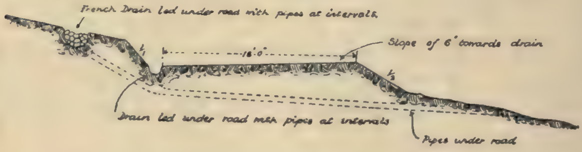
on top of upper flange, one on web, and one under lower flange ; each charge to be worked out according to the thickness of the flange or web in question by the formula given in para. 104.

A rule that works well for steel plates is to make the guncotton charge continuous and of the same thickness as the plate to be cut.

ROADS.

108. Gradients for military roads should not exceed 1/10, but for very short and straight distances may be 1/8. For main roads a steepest gradient of 1/20 should be aimed at.

109. When constructing a road on the slope of a hill, the drain should be on the inside of the road, and let under it at intervals with pipes or French drains ; this prevents the road being washed away in heavy rain.



—Section of Road on Slope of Hill in Ordinary Soil.—

110. A zigzag road ascending a hill should have its turns as wide and level as possible. Avoid sharp curves. For a cart road the minimum radius of a curve should be 45′.

111. Make the widths of roadways in multiples of 8′.

112. A suitable camber for a road is $\frac{1}{60}$th of width of road. This drains the road easily without being so steep as to be a source of danger or discomfort.

113. For temporary roads over boggy ground the most suitable foundation is a layer of brushwood—or better—fascines.

114. In cuttings in ordinary soil the slope of the sides should not be steeper than 1/1.

In hard soil the slope may be 2/1.

In embankments of ordinary soil the slope of the sides should not be steeper than 1/2.

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